Check for updates

Surgical Innovation
2023, Vol. 30(6) 762–765
© The Author(s) 2023
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/15533506231206038
journals.sagepub.com/home/sri
Sage

Design of a Compact Hologram System Capable of 3D Lesion Diagnosis in Clinic

Seung Yeob Ryu, BS[1,2,*,], Sangyun Lee, MS[1,*,**], Kicheol Yoon, PhD[1,*,**], Jeong-Heum Baek, MD, PhD[3], and Kwang Gi Kim, PhD[1,2,4]**

Abstract

Motivation: This paper proposes a small-sized hologram system for the 3D imaging of lesions in a clinical environment. In a general hologram system, the distance between the beam-generating device and the screen (400 mm) and the size of the screen must be increased proportionally to obtain excellent image quality. However, in a clinical environment, the beam spread distance and screen size must be reduced. This paper proposes a method for reducing the beam divergence distance and screen size for clinical applications.

Methods: To reduce the beam spread distance and screen size, a beam prism with a 45° refractive index is used to reduce the beam spread distance by 1/3. The direction of the bent light must be adjusted such that it can reach the screen accurately. However, because the reflected light may be refracted owing to the material properties of the mirror and cause loss, this problem can be solved by using a full reflection mirror.

Results: The beam spread distance of the designed hologram system is 200 mm. The types of lesions obtained from the 3D images of the hologram include the lung, liver, and colon. The image resolution is 300 × 145.

Conclusion: If the proposed method is used in a clinical environment, doctors can improve their understanding of the patient quickly and efficiently; thereby, shortening the treatment time. The proposed hologram system is expected to be useful in treatment rooms, operating rooms, and educational programs in medical schools.

Keywords
refraction, small size, full reflection mirror, beam prism, hologram

Introduction

In a doctor's office, it is difficult for a patient to understand a lesion from magnetic resonance imaging (MRI) and computed tomography (CT) data.[1] Generally, doctors provide easy explanations to help patients understand. However, it is difficult for the patient to explain their lesions. Therefore, communication between doctors and patients is difficult, and clinic hours are often delayed.[2] To solve this problem, lesion imaging data can be visualized in three dimensions to induce observation.[3,4] In doctors' offices, doctors and patients monitor at different viewing angles in a limited space, and excellent image quality and appropriate viewing size should be achieved with reduced distance.[5] This study proposes a method that can reduce the distance between the beam source and screen and provide a fixed viewing size and high image quality at various viewing angles.

Background and Design Methods

Background

The general hologram has a long distance between the irradiation beam source (B_1) and screen (S_a) for imaging observations of large size, as shown in Figure 1(a). If the irradiation distance increases, the image resolution also

[1]Medical Devices R&D Center, Department of Biomedical Engineering, Gachon University Gil Medical Center, Incheon, Republic of Korea
[2]Department of Biohealth & Medical Engineering Major, Gachon University, Seongnam-si, Republic of Korea
[3]Department of Surgery, Gachon University Gil Medical Center, Incheon, Republic of Korea
[4]Department of Health Sciences and Technology, Gachon Advanced Institute for Health Sciences and Technology (GAIHST), Gachon University, Incheon, Republic of Korea
[*]Seung Yeob Ryu, Sangyun Lee, and Kicheol Yoon contributed equally to this work.
[**]Seung Yeob Ryu, Sangyun Lee, and Kicheol Yoon are the co-first (lead) authors.

Corresponding Authors:
Jeong-Heum Baek, Department of Surgery, Gachon University Gil Medical Center, 14, Namdong-daero 774beon-gil, Namdong-gu, Incheon 21565, Republic of Korea.
Email: gsbaek@gilhospital.com

Kwang Gi Kim, Department of Biomedical Engineering, Gachon University, 38-19 Docjeomro NamdongGu, Incheon 21565, Republic of Korea.
Email: kimkg@gachon.ac.kr

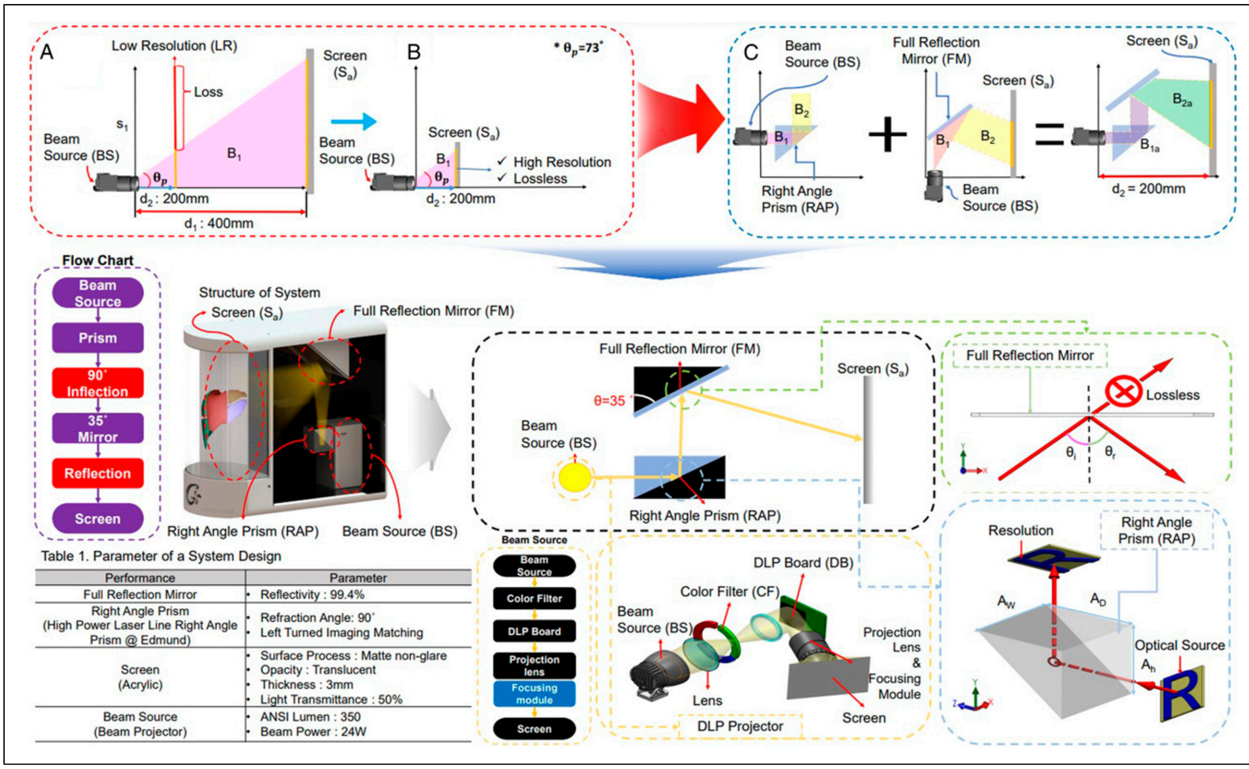

Figure 1. Flow of the development system and characteristic of the beam irradiation.

increases. Thus, the screen size of the conventional devices is large. However, the beam irradiation distance (d_2) of a conventional hologram system must be very short, as shown in Figure 1(b), and should be observed by the doctor and patient in the doctor's office. If the distance (d_2) of the irradiated beam decreases, the imaging size also decreases for observation on the screen (S_a), which reduces the resolution, whereas a small imaging size is difficult to observe. Gatebox reduces the distance between beam source and screen, but the image clarity is relatively poor and, the image is distorted by ambient light. To reduce the distance between irradiated beams, we attempted to overcome the limitations of the imaging size extension method on the screen (S_a). Figure 1(c) shows the proposed method for image size extension. For example, irradiation beams (B_{1a}//B_{2a}) can be separated using a beam prism (RAP) and a full reflection mirror (FM), in which the separated beams could be refracted in accordance with Snell's law. Therefore, the refracted beams (B_{1a}//B_{2a}) can be extended over a short distance (d_2), and the extended beam can be transmitted to the screen (S_a).

Design Methods

The designed system is composed of a beam projector (B_s), right-angle prism (RAP), full reflection mirror (FM), and screen, as shown in Figure 2. The beam projector (B_s) is the irradiated optical source, and a right-angle prism (RAP) is refracted with light directed at 90°. FM is adjusted to the light direction on the screen at 35°. In this study, the importance of the hologram was to decrease the throw distance between the beam projector and screen without changing the imaging resolution and distortion. To decrease the throw distance between the beam projector and screen, the light direction is refracted at 90°, which is used for the RAP. In addition, the RAP refraction light is reflected at 35° using FM.

System Test and Results

Figure 3 shows the proposed holograph system. As shown in the figure, the system is sufficiently miniaturized. To obtain the hologram results, output imaging was processed by 3D image rendering, and the output image is sent to a hologram system following the rendering process. The lungs, colon, and liver were imaged. In addition, imaging results for the lungs, colon, and liver were obtained using a hologram system. The photograph of the 3D imaging shows excellent front and lateral side views, which proves the reliability of the results.

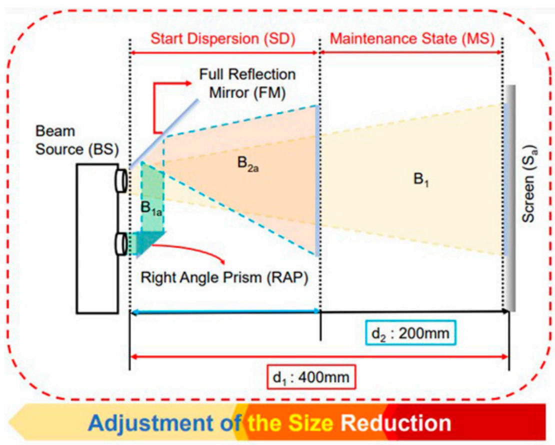

Table 2 : Comparison for analysis of the parameter characteristic

Performance	Parameters	
	Conventional type (without mirror using a prism)	Suggested type (with mirror using a prism)
Distance of the Beam Irradiation [mm]	400	200
Resolution (Diagonal [mm])	295	333
Resolution (W×H [mm])	260×140	300×145
Minimum Size of the Structure [mm]	≥450	≥350

Comparison for size of the conventional structure type and new structure (miniaturized size above the two times)

Figure 2. Comparison of the dimension with the new structure and conventional one.

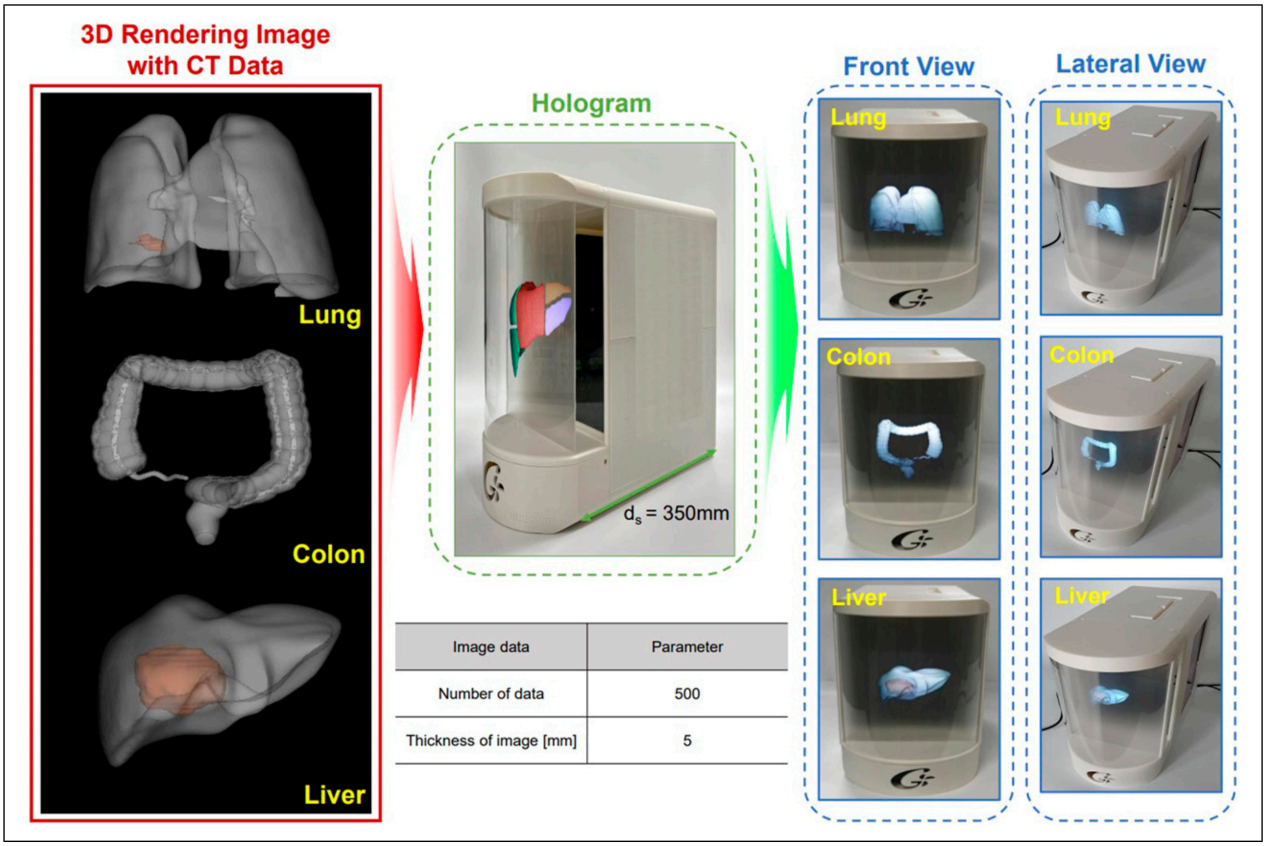

Image data	Parameter
Number of data	500
Thickness of image [mm]	5

Figure 3. Reliability of the test results using the proposed system with a hologram.

Discussion

If beam prisms and mirrors are used in the design process, it is crucial to focus the beam to maximize the beam deflection effect. If the beam is out of focus, the image quality will deteriorate, and the distortion will be severe. In addition, the beam focus problem causes scattering. Therefore, it is important to adjust the mirror angle. There have been no reports of developing a hologram system for use in a medical office. Typically, general holograms are used in stages. The proposed hologram was in the form of a gate box. Therefore, it is small and portable.

Conclusion

The cost of a Gatebox (GTBX-100JP, Japan) with hologram is 1127 USD[4] However, we suggested system will be decreased the 1/6 (cost). In this works, a miniaturized hologram system is designed to enable lesion observation (tumor location) in a clinical environment, including a doctor's office. A hologram system is used for beam prism and full-reflection mirrors (FM), which can be easily manufactured. Thus, the irradiation of beams must be non-distorted owing to lossless optical devices. The proposed adjustment of the refraction angle can reduce the beam irradiation distance. The proposed hologram system enables rapid and easy patient education in clinics. Therefore, the hologram system can be applied to surgery, operating rooms, emergency rooms, and medical school educational programs.

Author Contributions

Jeong-Heum Baek and Kwang Gi Kim are equally contributed. Jeong-Heum Baek and Kwang Gi Kim are co-corresponding authors. Seung Yeob Ryu, Sangyun Lee, and Kicheol Yoon contributed equally to this work. Seung Yeob Ryu, Sangyun Lee, and Kicheol Yoon are co-first (lead) authors. Seung Yeob Ryu worked on the concept and design of the study, and Sangyun Lee performed the analysis and interpretation. Kicheol Yoon performed the simulations and documented the investigation. Kwang Gi Kim supervised the study, and Jeong-Heum Baek provided clinical information.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Technology Innovation Program (K_G012001185604, "Development of Diagnostic Medical Devices with Artificial intelligence Based Image Analysis Technology") funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea). In addition, the research work was supported by Gachon University Gil Medical Center (FRD2020-19), and Gachon University (GCU-20220598001), respectively.

ORCID iD

Kwang Gi Kim https://orcid.org/0000-0001-9714-6038

Supplemental Material

Supplemental material for this article is available online.

References

1. Ahn JM. Holography technologies and market trends. *Convergence Weekly TIP of Convergence Research Center* 2017;7:54.
2. Kim M, Yoon KC, Kim KG. Design of the floating hologram method with a reverse pyramid type for CT and MR diagnosis in clinical room. *Diagnostics*, 2022;12(5): 1157.
3. Choi JH, Kim J.. Study on the production of interactive multimedia content using floating holograms. *J Digit Contents Soc*. 2018;19(9):1625-1630.
4. Gatebox. *Gatebox's Azumi Hikari*. Tokyo: Gatebox; 2017. web site on www.gatebox.ai.
5. Muhammad Abdullah AB, Lsmail Fairos NA, Sunar MS. Reflective prism display using pepper's ghost technique software toolkit plugin for unity 3D. *J Teknol*. 2016;78(12): 189-196.